BETTER PASTURES *for* DAIRY CATTLE

By W. B. Nevens

etin 505
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ACKNOWLEDGMENT

Grateful acknowledgment is made to other members of the staff for assistance in the planning and execution of this investigation, which was conducted as a joint project in cooperation with the Departments of Agronomy and Animal Husbandry. The late John J. Pieper, Chief in Crop Production, proposed the rotational, or alternate, grazing plan and the crops to be used in it. Many of the details were later carried out almost exactly as he outlined them in the plan drawn up prior to the beginning of the field work. Valuable assistance was also rendered by several other members of the Department of Dairy Husbandry, including K. E. Harshbarger, K. A. Kendall, A. F. Kuhlman, E. E. Ormiston, and W. W. Yapp.

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BETTER PASTURES FOR DAIRY CATTLE

By W. B. Nevens, Chief in Dairy Cattle Feeding

PASTURE FORAGE, altho it does not by itself supply enough nutrients for high-producing dairy cows, is the most nearly ideal feed for them. During May and June, the peak of the pasture season, milk yields for the country are more than 50 percent higher than at any other time of the year. Fresh, green pasture crops also keep cattle in good health and promote the growth of heifers and young bulls.

Pasturing is much cheaper than barn-feeding. For example: In a survey made by the U. S. Department of Agriculture in seven districts, cows were found to be getting nearly one-third their nutrients from pasture at a cost of only one-seventh the total feed cost.[1] And in a study of specialized New York dairy farms made in 1936, the cost of pasture was found to be only 4 percent of the total milk-production cost in spite of the fact that cows were pastured for 149 days of the year.[2]

Pasturing is also less work than barn-feeding. Not only do the animals do their own harvesting, but it also takes less labor to produce pasture crops than other crops. For example: on the same New York dairy farms mentioned above 154 man-hours a year were required to take care of each cow: 45 man-hours during the pasture season and 109 man-hours during the winter season. On the average farm in the United States it takes about 140 man-hours a year to take care of a cow.[3]

Illinois grasses such as bluegrass, redtop, and timothy, however, do not yield enough forage in midsummer to enable dairy cows to maintain good milk yields. Their protein content also declines when they begin to ripen. Cows on such pastures must receive a supplementary feed or their milk production falls off and cannot be restored until the next lactation period.

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[1]Cited by Semple, A. T., *et al.* A pasture handbook. U. S. Dept. Agr. Misc. Pub. 194. 1934.

[2]Misner, E. G. Economic studies of dairy farming in New York. N. Y. (Cornell) Agr. Exp. Sta. Bul. 696. 1938.

[3]Elwood, R. B., *et al.* Changes in technology and labor requirements in livestock production: dairying. U. S. Dept. Agr. Bur. Agr. Econ. W.P.A. Report No. A-14. 1941.

PLAN OF EXPERIMENTS[1]

The object of the experiments reported herein, which were conducted at the University of Illinois from 1935 thru 1942, was threefold:

1. To develop a pasture system that would supply ample forage during midsummer.

2. To evaluate alfalfa (*Medicago sativa*), Kentucky bluegrass (*Poa pratensis*), bromegrass (*Bromus inermis*), winter rye (*Secale cereale*), sweet clover (*Melilotus alba*), and a mixture of Sudan grass and soybeans (*Andropogon sorghum sudanesis* and *Soja max*) as pasture crops for dairy cattle.

3. To increase the yield and protein content of Kentucky bluegrass.

Highly productive soils used for pastures. In 1935 two tracts of the Dairy Husbandry farm were fenced off into pastures. Both tracts were slightly rolling, with a gentle slope and drainage to the southwest. The tract west of the barns was divided into three fields of 4½ acres each and four fields of 2¼ acres each, and the tract north of the barns was divided into four fields of 4½ acres each (page 230).

The soil, all tillable, was identified as follows:[2]

Tract west of the barns. A considerable portion of this field is underlain by outwash sands. Two soils occur in this outwash area, Brenton silt loam and Drummer clay loam. The highest portions of the field are occupied by Catlin silt loam and the lower portion of the slopes bordering the outwash by Flanagan silt loam.

Tract north of barns. The soil pattern on these fields is rather complex. The same soils occur as on the field west of the barn but in a more complex pattern.

All are prairie soils. Catlin is subject to erosion, while the major problem on Drummer is drainage. Drummer underdrains well, but its topographic position makes surface drainage slow. The agricultural-value ratings[3] of these soils are: Catlin, 3; Flanagan, 2; Brenton, 2; Drummer, 1.

Three fields (Nos. 5, 6a, and 6b) were planted to bluegrass and grazed as a pasture unit each season. All of the remaining fields (except a few not grazed at all some seasons) were planted to a number of different crops, including bluegrass on Field 7a, and grazed

[1]For reviews of pasture research literature, see references on page 271.

[2]May 3, 1943, by R. S. SMITH, Chief in Soil Physics and Soil Survey.

[3]The number indicates the ability of the soil type to produce the major crops grown in the region, without soil treatment but with the soil in a cleared and drained condition. The scale is 1 to 10, the most productive soil in the state being rated as 1 and the least productive as 10.

Experimental pastures. This gently rolling, highly productive land yielded large amounts of forage. It was all tillable and could have grown equally good yields of intertilled crops.

in rotation as a comparable unit thru 1941 and as two comparable units in 1942.

Lime and manure were principal fertilizers. Both tracts had been limed before the experiments were started. When alfalfa was planted in the spring of 1935, the north tract received another light application of limestone (about 1,000 pounds to the acre). This was applied by using a seed drill with a fertilizer compartment.

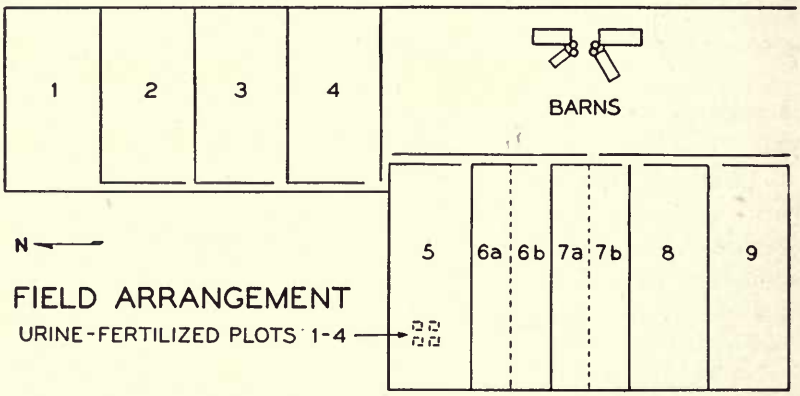
The last four seasons (1939-1942) four small bluegrass plots (each 2 rods by 2 rods) were treated with cow urine.

The only other fertilizer applied during the experiments was barn-

Large amounts of barnyard manure were applied to the experimental plots. Adequate fertilization is one of the most effective ways of improving pastures. It was responsible in large part for the high yields on these plots.

yard manure. On the two-crop fields (rye and a combination of Sudan grass and soybeans) it was plowed under with the ripened rye just before the Sudan-soybean mixture was planted. The one-crop fields (alfalfa, bluegrass, bromegrass, and sweet clover) were top-dressed during the barn-feeding season. The usual rate of application was 10 to 12 tons an acre.

Forage yields measured by samples. Two sampling sites were located in typical parts of each field, and a small amount of forage was harvested from each location just before each crop was grazed and at monthly intervals thru the season. This not only made possible the cal-



Arrangement of experimental pastures

culation of acre-yields but also gave much information about the dry-matter and weed contents. In some cases chemical determinations of protein and other substances were made also.

Method of harvesting.—The forage was harvested by means of grass shears and a metal frame 44 inches square and 1½ inches high. A flat bar slid across the frame and guided the shears so that they cut all forage at the same height.

The forage was collected in cloth sacks and taken to the laboratory to be sorted by hand into weed and grass portions. Each portion was then resacked in a tared cloth sack, weighed, and dried in a constant-temperature oven at 92° to 100° C.

The A method of measuring monthly growth.—On the first sampling date each season, just before cattle were turned onto pasture, one 44-by-44-inch area was harvested at each sampling location. A

re-enforced woven-wire cage 48 inches square and 26 inches high was then placed over the area to prevent the cattle from grazing it. (When necessary, two such cages, one above the other, were placed over tall crops like winter rye and Sudan grass.)

The forage taken from the two caged areas on each field a month later represented one month's growth and was called the A sample.

The frequent cutting, however, sometimes discouraged growth and made **A** samples not always accurate. So, as a check, the monthly growth was also measured by the **B** or **B**-minus-**C** method.

B or B-minus-C method of measuring monthly growth.—On the first sampling date of the season a wire cage was placed over a 44-by-44-inch area of open pasture at each sampling location. The forage from these two caged areas a month later was called a **B** sample. It represented one month's growth plus whatever forage had been on the open pasture on the previous sampling date.

The amount of forage from two 44-by-44-inch areas on open pasture on any given date was called a **C** sample.

One month's growth, therefore, was represented by the current B sample minus the C sample of the previous month.

The cage was then replaced over the **B** area to make next month's **A** sample.

The A method of measuring monthly yield.—As the forage for each sample was harvested from $\frac{1}{1620}$ of an acre (two 44-by-44-inch areas), the weight of the **A** sample was multiplied by 1620 to get the monthly yield per acre. The seasonal yield was obtained simply by adding the monthly yields as determined by the **A** samples.

Taking samples of forage. The men are taking a **C** sample of rye from open pasture. The near cage will be placed over the harvested area to make next month's **A** sample. The cage in the background protects next month's **B** sample.

The B-minus-C method of measuring monthly yield.—To get the monthly yield per acre by the **B**-minus-**C** method—also called the difference method—the **C** sample of the previous month was subtracted from the **B** sample of the current month and the difference multiplied by 1620.

Final computing of yearly yields.—In the case of bluegrass and bromegrass, yields obtained by the **A** method tallied with those obtained by the **B**-minus-**C** method. For such crops as sweet clover and soybeans, however, only the **B**-minus-**C** method was satisfactory: the low cutting of sweet clover during its second year killed the plants, and the low cutting of soybeans either killed them or greatly retarded their growth.

The monthly and seasonal yields cited in these experiments were computed from whichever of the two methods was better adapted to the purpose or, in some instances, from the average of the two methods.

Grazing used as final test of pastures. A pasture cannot be judged just by sampling tests. The only sure way to find out whether the crop is palatable and will provide enough digestible nutrients thru the season is by grazing it. Actual grazing is also the only way to find out whether the new pasture will cause physical upsets such as bloat and diarrhea or impair the flavor and the composition of milk.

The experimental pastures were therefore tested by grazing cattle on them as well as by sampling. Two systems of grazing—the bluegrass system (bluegrass alone) and a rotational system (various crops in succession, each crop usually being pastured a week or two at a time) —were tried out.

The two systems were rated according to (1) the number of days they were pastured, (2) pasture days supplied per acre, (3) weight gained by cattle per head, (4) weight gained per acre, and (5) weight maintained per acre.

1935-1936. 1935 and 1936 were devoted mostly to studying methods of grazing research. In 1935 the experimental animals were milk cows; in 1936 they were milk cows and yearling heifers. Supplementary feeding was also practiced.

1937-1942. Two variables in results—the change in milk yield and the change in weight—plus the variable amount of supplement fed made it hard to evaluate the pasture crops accurately for the two previous years. The 1937-1942 experiments were therefore simplified so there would be just one variable—the change in weight. Only heifers six months to two years old were pastured and no supplement was fed except salt.

From 1937 thru 1941 the heifers were divided into two groups each season. Group I was pastured on a rotational system, being moved from one plot to another as the different crops were ready to be grazed. Group II was pastured exclusively on Kentucky bluegrass.

In 1942 two separate systems of rotational grazing were tried out. Two separate groups of heifers (I and IA) were therefore pastured on the rotational crops. Another group (II) was pastured on the Kentucky bluegrass.

ROTATIONAL GRAZING HAS ADVANTAGES

The rotational system proved superior to bluegrass alone because: (1) the rotational season was longer; (2) heifers on the rotational system gained more weight both per head and per acre; and (3) the rotational system maintained more weight per acre (Table 1).

More Days on Pasture

The rotational system provided an average of 149 days of pasture a season; the bluegrass system, 132. The season was usually longer for the rotational system because (1) heifers could be turned to pasture earlier in the year (Table 1), and (2) the crops withstood dry weather better than bluegrass did.

Pasture days per acre were figured by multiplying the number of days on pasture by the number of heifers and dividing by the area of the pasture in acres:

$$\text{Pasture days per acre} = \frac{\text{Days on pasture} \times \text{Number of heifers}}{\text{Area of pasture in acres}}.$$

The yearly average for bluegrass alone was 185 pasture days an acre; for rotational crops, 166. These figures, however, do not indicate how much forage the heifers on either system ate and are therefore of only nominal value.

More Weight Gained per Head and per Acre

Heifers on rotational grazing gained a yearly average of 36 pounds a head more than heifers on bluegrass alone. The average yearly gain per acre was also larger (20 pounds more) for the rotational system than for bluegrass.

Only once, in 1939, were the gains of heifers on rotational grazing unsatisfactory. Early that season, because of dry weather, the heifers had to be taken off pasture and fed in drylot for nearly four weeks.

TABLE 1.—GRAZING TRIALS, 1937-1942

Pasture system	Field	Total pasture area	Heifers pastured	Number of days on pasture	Pasture days per acre	Live weight gained		Live weight maintained per acre
						Per head	Per acre	
1937								
I—Rotation system (*May 7-Sept. 21*)		*acres*				*lb.*	*lb.*	*tons*
Alfalfa	9	4.50	20	52	231	...	...	....
Bluegrass	7A	2.25	20	21	187	...	...	....
Winter rye	7B	2.25[a]	20	8	71	...	...	....
Sudan-soybeans	7B, 8[b]	6.75	20	56	166	...	...	....
Sweet clover	8	4.50[b]	20	1[b]	...	...	...	....
Totals and averages								
Acre basis	....	13.5[a]	20	138	204	160	237	77.9
Utility basis	....	12.00[c]	20	138	230	160	267	87.6
II—Bluegrass alone (*May 7-Sept. 1*)	5, 6	9.00	10	117	130	128	142	64.6
1938								
I—Rotation system (*Apr. 21-Sept. 21*)								
Alfalfa	1, 9A	6.75	16	48.5	115	...	...	....
Bluegrass	7A	2.25	16	37	263	...	...	....
Winter rye	7B, 8	6.75[a]	16	17.5	41	...	...	....
Sudan-soybeans	7B, 8, 9B	9.00[d]	16	51	91	...	...	....
Totals and averages								
Acre basis	....	18[a]	16	154	137	135	120	70.5
Utility basis	....	17.25[e]	16	154	143	135	125	73.7
II—Bluegrass alone[q] (*Apr. 21-Oct. 5*)	5, 6	9.00	10	167	186	184	205	71.2
1939								
I—Rotation system (*May 7-Sept. 20*)								
Bluegrass	7A	2.25	10	32	142	...	...	....
Winter rye	7B, 9A	4.50[a]	10	27	60	...	...	....
Sudan grass	7B, 9A, 9B	6.75	10	53	79	...	...	....
Totals and averages								
Acre basis	....	9[a]	10	112[f]	124	80	89	57.6
Utility basis	....	8.25[e]	10	112[f]	136	80	97	62.8
II—Bluegrass alone (*May 7-Sept. 17*)	5, 6	9.00	10.6[g]	134	155	85	100	58.0
1940								
I—Rotation system (*May 3-Sept. 25*)								
Alfalfa	3	4.50[h]	18	10.25	41	...	...	....
Bluegrass	7A	2.25	18.3	14	114	...	...	....
Winter rye	4, 7B	6.75[ad]	19	26	73	...	...	....
Sudan-soybeans	4, 7B, 9	11.25	18	76.25	122	...	...	....
Sweet clover	8	4.50[i]	19	19.5	82	...	...	....
Totals and averages								
Acre basis	....	22.5[a]	18.3[k]	146	119	165	134	47.7
Utility basis	....	17.25[aj]	18.3[k]	146	155	165	175	62.2
II—Bluegrass alone (*May 6-Aug. 5*)	5, 6	9.00	14	90	140	60	93	43.1

(*Table is concluded on page 235*)

In 1938 the heifers on rotational crops gained 135 pounds a head; heifers on "bluegrass alone," 184 pounds a head. Much of this remarkable "bluegrass" gain, however, which was 56 more pounds per head than during the second-best bluegrass year, 1937, was due not to blue-

TABLE 1.—GRAZING TRIALS, *Concluded*

Pasture system	Field	Total pasture area	Heifers pastured	Number of days on pasture	Pasture days per acre	Live weight gained		Live weight maintained per acre
						Per head	Per acre	
1941								
I—Rotation system (*May 1-Oct. 16*)		*acres*				*lb.*	*lb.*	*tons*
Alfalfa	3	4.50[h]	20	22	98	...	...	....
Bluegrass	7A	2.25	20	16.5	147	...	...	....
Bromegrass	1, 2	9.00	20	80.5	179	...	...	....
Winter rye	7B, 9A, 9B	6.75[a]	20	12	35	...	...	....
Sudan-soybeans	7B, 9A, 9B	6.75[a]	20	37	110	...	...	....
Totals and averages								
Acre basis	....	22.5[a]	20	168	149	120[l]	107[m]	62.7
Utility basis	....	21.00[h]	20	168	160	120	114	67.4
II—Bluegrass alone (*May 7-Oct. 23*)	5, 6	9.00	14	170	264	115	178	68.8
1942								
I—Rotation system (*Apr. 22-Oct. 2*)								
Bromegrass-alfalfa	3	4.50	13.7	56	171	...	...	....
Bromegrass	1, 2	8.50	13.5	91	145	...	...	....
Winter rye	4	4.50[n]	14.0	17	53	...	52	....
Totals and averages								
Acre basis	....	17.5	13.6[o]	164	127	119	92	64.4
Utility basis	....	14.50	13.6[o]	164	154	119	111	68.2
IA—Rotation system (*Apr. 22-Oct. 2*)								
Bromegrass	8	4.5	10	100	220	...	...	....
Winter rye	7B, 9A	4.5[a]	10	28	62	...	74	....
Sudan-soybeans	7B, 9A	4.5	10	36	80	...	...	....
Totals and averages								
Acre basis	....	9.0[a]	10	164	181	123	136	71.0
II—Bluegrass alone (*May 6-Oct. 2*)	5, 6	9.0	14.3[p]	150	238	75	119	75.8
Average per year, 1937-1942								
Rotation systems (acre basis)	.....	...	149	149	129	131	64.6
Rotation systems (utility basis)	.....	...	149	166	129	146	70.4
Bluegrass alone	.....	...	138	185	108	140	63.6
Bluegrass alone, omitting 1938[q]	.....	...	132	185	93	126	62.1

[a]The Sudan-soybean mixture was planted on the same field as rye. [b]The sweet-clover crop was a failure. After one day's pasturing, the field was planted to Sudan grass and soybeans. [c]Because of the failure of the sweet clover, it was estimated that Field 8 was utilized at only two-thirds of its capacity. [d]Field 9B was not used for rye pasture this season.

[e]Pasture days per acre for rye averaged 56; for Sudan grass and soybeans, 108. A field planted only to Sudan-soybeans was estimated to be utilized at only two-thirds of its capacity. [f]Because of low rainfall, the heifers on rotational grazing were fed silage and hay in drylot from June 29 thru July 23. [g]At the beginning of the season, Group II consisted of 14 heifers. Four were removed on June 7 because the grass was insufficient, and one was removed August 1 because of illness. [h]It was estimated that the first cutting of alfalfa for hay or silage removed one-third of the pasturage for the season. [i]As sweet clover was not pastured after July 13, it was estimated that Field 8 was utilized at only half its capacity.

[j]See notes d, f, and g above. [k]One heifer was removed June 19. [l]Heifers gained an average of 144 pounds per head from May thru September 19 but lost 24 pounds per head during the period of unusually heavy rainfall from September 19 to October 16. [m]Gain to September 19 was 128 pounds an acre. [n]This field was not used after the rye season ended and was therefore rated at only one-third of its pasture-producing capacity.

[o]One heifer was removed August 4. [p]At the beginning of the season 20 heifers were pastured on bluegrass alone. Six were removed on July 1 and eight more on August 26. [q]The remarkable gains that the heifers on bluegrass alone made this season were due, in great part, to the volunteer sweet clover which sprang up in the bluegrass pastures.

grass alone but to volunteer sweet clover. Also seasonal rainfall, till September, was above normal and unusually well distributed (Table 2). In order to make a fair comparison of the two pasture systems, therefore, the 1938 figures for bluegrass alone must be discounted. This has been done thruout this report.

TABLE 2.—WEEKLY RAINFALL AT URBANA DURING THE GRAZING SEASONS 1935-1942
(Inches)

	1935	1936	1937	1938	1939	1940	1941	1942
April 1-8	1.10	1.56	2.34	2.92	.70	.82	1.37	2.11
April 9-15	.80	.06	.61	....	2.90	1.04	.66	.80
April 16-23	.23	.25	1.49	.14	1.72	1.27	2.18	.20
April 24-30	.74	2.30	.96	.36	.07	.83	....	.21
May 1-8	3.60	1.42	1.36	.40	.26	1.50	2.08	.85
May 9-15	1.58	.46	.01	.64	.06	.55	.89	2.48
May 16-23	1.01	1.00	1.22	3.08	.56	1.31	.89	.24
May 24-31	.74	1.06	....	.85	.31	1.17	.08	....
June 1-8	.31	.26	3.13	.64	.47	1.43	.58	1.46
June 9-15	.13	.09	.82	1.60	3.61	1.40	3.69	1.46
June 16-23	2.39	.01	.60	....	1.19	.63	.36	.42
June 24-30	.81	.11	.88	3.43	.90	1.58	1.56	.58
July 1-8	1.72	....	.10	1.36	.99	....	1.79	2.81
July 9-15	.84	.43	1.59	.10	....	.80	.02	1.05
July 16-23	.64	.10	....	2.46	.74	.02	1.00	.30
July 24-31	.92	.82	.74	2.53	....	.13	.46	.78
August 1-8	1.30	.56	.19	1.77	1.43	.29	.05	.16
August 9-15	.80	1.58	.44	.11	1.06	.33	1.12	.67
August 16-23	.20	.48	.17	1.55	3.89	.52	.89	.18
August 24-31	.06	.92	....	.85	....	1.66	1.58	1.57
September 1-8	1.11	.77	....	.05	.04	....	2.19	.83
September 9-15	1.11	1.38	3.12	.24	....	.48	1.21	.02
September 16-23	.01	.07	....	.59	.11	....	....	2.06
September 24-30	1.71	3.61	2.22	....	.17	....	1.51	.95
October 1-8	.04	.48	.82	....	.93	.99	3.61	.10
October 9-15	.44	.86	.33	.71	1.16	.42	1.11	.23
October 16-23	.37	.99	2.77	1.79	....	....	2.44	.16
October 24-31	.80	1.16	....	....	.45	.52	1.85	1.87
Total for 7 months	25.51	21.62	25.89	28.17	23.72	19.69	35.17	24.55
Total for year	37.21	35.09	37.65	42.77	38.05	30.60	42.87	42.38

More Weight Maintained per Acre

Yearling heifers are usually expected to gain from ¾ to 1 pound daily until they approach nearly full size. Some heifers in these trials, however, already weighed 800 to 1,000 pounds at the beginning of the pasture season. The gain of groups with several such heifers was, of course, rather small and not a complete measure of the value of the pasture system. Not only the weight gained but also the weight maintained must therefore be taken into account.

On the whole, rotational crops maintained more weight on the heifers per acre of grazing than bluegrass alone. The rotational system carried more weight in four seasons (1937-1940) and the bluegrass system carried more weight in two seasons (1941 and 1942).

The weight maintained per acre was computed by multiplying the average weight (average of three consecutive daily weights taken at monthly intervals) by the number of days on pasture and dividing by the number of acres in the pasture system:

$$\text{Live weight maintained} = \frac{\text{Average live weight} \times \text{Days on pasture}}{\text{Acres in pasture system}}.$$

Bluegrass Suffered Most From Dry Weather

The heifers always gained more weight when rainfall was abundant and well distributed. Dry spells during the season reduced the total yields of both the bluegrass and the rotational systems. All the other crops, however, proved more resistant to dry weather than did bluegrass.

The best example of the relative staying power of the two pasture systems during dry weather is found in the 1940 test. That year, altho the rotational season lasted 146 days, bluegrass could be pastured only 90 days. Heifers on the rotational system gained 165 pounds a head; those on the bluegrass gained only 60 pounds a head. The gain per acre for rotational crops was 175 pounds; for bluegrass, only 93 pounds.

Bluegrass pastures need supplementing in midsummer. This pasture was almost bare on August 8, 1936, a season of low rainfall. Compare with the alfalfa pasture shown on page 244, photographed the same day. Occasionally well-distributed showers keep bluegrass pastures producing well in midsummer, but usually barn feeding or supplementary pastures are needed.

Bluegrass was at its best when rainfall was heavy and frequent. In 1941, for example, the very heavy rainfall in September and October made it practicable to pasture bluegrass until October 23. The gain per acre that year was 178 pounds for bluegrass, 114 pounds for rotational crops. These late heavy rains not only muddied the bromegrass fields but evidently caused less forage to be eaten, for the heifers on the rotational system lost 24 pounds a head during the last month of grazing.

CROPS HAVE DIFFERENT MERITS

It is to the advantage of a dairy farmer to plan a pasture system that will provide an ample supply of nutritious and palatable forage as long as possible. Individual crops should be rated according to (1) their feeding value, (2) palatability, (3) economy of production, (4) amount and timeliness of yield, (5) length of pasture season, (6) resistance to drouth, weeds, and tramping, (7) likelihood of causing bloat or other upsets, and (8) adaptability to soil and climate.

Winter Rye Is Earliest

Winter rye is a highly palatable early pasture crop. It has a large yield (Tables 3 and 4) and is practically free from weeds. It can be planted in the fall after corn for silage is harvested or Sudan grass pastured, and plowed under in the spring in time to plant corn or Sudan grass again.

Rye, however, develops so rapidly when the weather becomes warm that not all the forage can be used and much is lost by tramping. As ripening nears, palatability declines greatly. Since the sod is loose, it cannot be pastured immediately after a heavy rain. Sometimes, too, rye impairs the flavor of milk, altho this difficulty can be overcome by feeding hay in addition and by pasturing cows on the rye only after they have been milked and only for a few hours a day.

Winter rye (1.5 bushels to the acre) was planted with a grain drill late in September or early in October after the pasturing of Sudan grass. As it was unable to get a good start in the fall, it was less

Winter rye was first crop ready for grazing. Seeded the previous autumn, it made good early pasture. Cattle were turned onto it about May 1 in most years, as early as April 15 one year. Picture was taken on May 10.

Winter rye makes extremely rapid growth. Under favorable conditions growth is so rapid that it is hard to utilize it. In its early stages winter rye combines two qualities of good dairy feed: high palatability and high protein content.

vigorous in the spring than rye planted in late August or early September would have been.

When the crop residue on the field was small, a satisfactory seedbed was prepared by disking instead of plowing.

Rye was the first crop to be pastured under the rotational system and was usually ready a week or two before bluegrass (Table 1). It was grazed either until forage gave out or until it began to mature and

Too far advanced for good pasture. By May 9 hot weather had caused this rye to develop so rapidly that the cattle could not eat it fast enough to prevent its heading out. As ripe rye is unpalatable, much forage went to waste. This crop was followed by Sudan and soybeans.

TABLE 3.—DRY-MATTER YIELDS OF FIVE PASTURE CROPS ON FIRST SAMPLING DATES, 1937-1942
(Pounds per acre)

Crop	May 6, 1937	April 26, 1938	May 5, 1939	May 2, 1940	April 29, 1941	April 23, 1942	April 30, 1942
Alfalfa	1 240	580	...	...	920	540	...
Bluegrass	690	690	460	300	590	...	600
Bromegrass	...	...	...	...	1 690	1 030	...
Sweet clover	...	...	...	500	...	...	...
Winter rye	2 040	2 530	1 710	990	1 120	2 660	...

the heifers would not eat it anymore. The longest season was 28 days, April 22 thru May 19, in 1942. The average season was 19 days.

In these experiments barnyard manure was spread on the fields as soon as rye pasturing was discontinued, and the land was then plowed and planted to a mixture of Sudan grass and soybeans.

Bluegrass Recovers Best From Close Grazing

Bluegrass usually makes excellent pasture in late spring. When green it supplies very palatable forage, and it recovers from too close and too early grazing better than other pasture crops. It is also a good emergency pasture after heavy rainfall, when grazing would injure crops that do not form a firm sod, and is a good reserve pasture when cattle are being accustomed to a legume. Bluegrass pastures given reasonable care can be maintained over an indefinite period of years with but little expense for labor and seed.

As bluegrass approaches maturity, however, it declines markedly in yield and protein content and palatability. Usually the amount and quality of forage supplied during July and August are too small and

TABLE 4.—ANNUAL DRY-MATTER YIELDS OF FIVE PASTURE CROPS
(Pounds per acre)

Crop	1937	1938	1939	1940	1941	1942
Alfalfa	5 900	5 950	.....	.....	6 600	6 700
Bluegrass	2 750	4 300[b]	2 750	2 950	3 600	4 450
Bromegrass	.....	.....	.....	.....	7 150	5 550
Winter rye	2 050	3 650	4 150	4 100	2 700	3 100
Sudan-soybeans	4 600	4 850	5 100	5 900	8 800	6 500
Total for rye and Sudan-soybeans[a]	6 650	8 500	9 250	10 000	11 500	9 600

[a]The Sudan grass and soybean mixture followed winter rye on the same field in the same pasture season. [b]Includes volunteer sweet clover.

too poor to support milk yields of high-producing cows. Production drops and cannot be restored, a situation that causes great loss. A shortage of feed for growing heifers for a time is much less serious, as normal gains in weight can be restored after a period of no gains.

Another disadvantage of bluegrass is that the season for it begins later, the forage contains more weeds, and the yearly yield is lower than that of most other pasture crops grown in central Illinois.

Each year except in 1942 a small bluegrass field (7a) was pastured immediately after rye in the rotational system. The field was also used intermittently thru the grazing season for an emergency and reserve pasture.

If winter rye or the mixture of Sudan grass and soybean had been pastured right after a heavy rain, the ground would have been severely tramped and the crop injured. After heavy rains, therefore, heifers that were on rye or Sudan-soybeans were transferred to the bluegrass field for a day, sometimes for two or three days.

The bluegrass field also served as a paddock and reserve while heifers were being accustomed to alfalfa and sweet clover. For the first few days heifers were pastured on the legumes for periods ranging from only half an hour to an hour and spent the rest of the day on the bluegrass field.

The days on pasture and the pasture days per acre credited to the 2½-acre bluegrass field in Table 1 have small significance, however, because the field sometimes furnished little or no forage.

Bluegrass makes good reserve pasture. From the end of the rye season till the beginning of the Sudan-soybeans season, bluegrass served as a good reserve pasture. It was also good emergency pasture whenever heavy rains made the sod of winter rye or Sudan-soybeans too soft to pasture for a day or two. Picture was taken on June 15.

Effect of good management. The experimental bluegrass pastures were well managed. Barnyard manure was applied regularly. Cattle were turned to pasture only after the grass had made a good start and were removed in the fall in time to permit late fall growth of the grass. Large weeds, such as dock and thistles, were dug out by

Bluegrass responds to good management. This well-managed pasture was supplying an abundance of forage on July 4, when most bluegrass pastures are bare. Cattle were turned on bluegrass only after it had made a good start and were taken off in time to permit late fall growth.

hand. In seasons of low rainfall cattle droppings were broken up and spread by a tractor-drawn harrow. Attempts were also made to adjust the number of cattle to the amount of forage.

As a result of these management procedures, the experimental bluegrass pastures not only supplied twice as much forage as comparable pastures poorly managed, but the forage was also much higher in feeding value.

Alternate versus continuous grazing of bluegrass alone. Field 5 was grazed continuously every season. During 1937, 1938, and 1939 Fields 6a and 6b were grazed alternately at two-week intervals. But no difference in yield or other supposed benefits of alternate grazing were observed; so after 1939 the alternate grazing was discontinued.

One reason that alternate grazing did not benefit these experimental bluegrass pastures may have been that they were not stocked heavily,

Not a good early-season pasture. A great disadvantage of bluegrass as the sole pasture crop is its failure to produce enough forage early in the season. Compare this pasture with the rye shown below. Pictures were taken on the same day, April 26.

for rotational grazing did greatly benefit Sudan grass and other crops injured by close grazing. During the rest periods growth was hastened, and rains, which washed some of the cattle excrement into the soil, freshened the forage.

Abundant winter rye on April 26. Winter rye furnished nearly as much forage (dry-matter basis) during the 2- to 4-week period it was pastured as a comparable field of bluegrass did during the entire season.

Alfalfa Makes Excellent Late Pasture

Alfalfa is high in yield (Table 4) and palatability and resists dry weather well. If pastured in the spring, however, it is likely to cause bloat; and in areas where it is subject to plant diseases, the stand becomes thin and weedy within two or three years.

In 1937 and 1938 alfalfa was pastured over a period of about 3½ months—from about the first of June to the middle of September. Such early pasturing was inadvisable, as some animals, despite careful watching, developed mild cases of bloat. In 1940 and 1941, therefore, the first crop was removed for hay, and pasturing was begun in late June or early July.

Alfalfa is resistant to dry weather. Altho lack of rainfall reduces yields to some extent, the experimental alfalfa pastures continued to produce well during dry weather. Compare with bluegrass (page 237) on the same date, August 8, 1936.

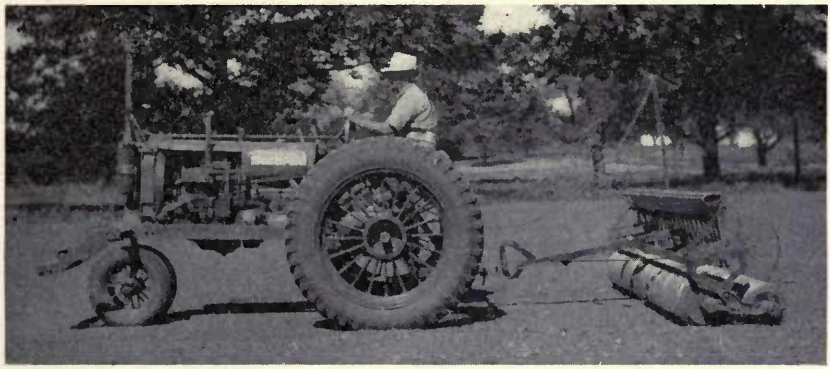
The alfalfa-bromegrass mixture seeded in the fall of 1939 produced a crop that consisted largely of alfalfa in 1940 and 1941. By 1942, however, the crop was composed of nearly equal parts of alfalfa and bromegrass.

Alfalfa furnished palatable green forage in the late summer of 1937 and thru most of the summer of 1940, when bluegrass furnished no feed at all.

Alfalfa proved satisfactory for two seasons after the first seeding. The third season bacterial wilt weakened the stand so much that the weeds almost overran the alfalfa and the field had to be reseeded. (In order to control disease other crops should usually be grown for a few years before alfalfa is replanted in the same soil.)

Reseeding was a serious disadvantage in these experiments where pasture space was limited because (1) the seed cost per acre was high, (2) pasture was lost during the year of reseeding, as spring planting required the use of a nurse crop and late-summer planting required summer fallowing to control weeds.

Reseeding is not, however, a serious disadvantage on farms where crops are grown in rotation, for the alfalfa can be planted either in



Alfalfa seeding simplified. The seed passes from the seed box thru the tubes and between the corrugated rollers. The machine also helps to prepare the seedbed and turns a light covering over the seed, all in one operation.

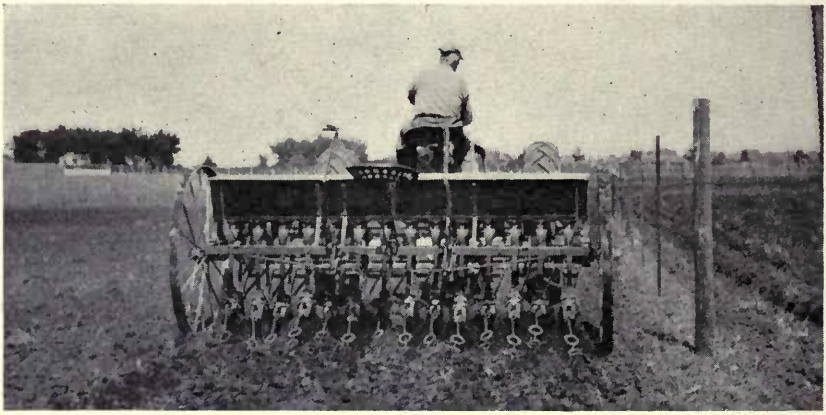
the spring with a grain like oats or in late summer after an early pasture crop like rye, an early hay crop like soybeans, or an early canning crop such as peas.

Sudan-Soybeans Good Supplementary Pasture

A mixture of Sudan grass and soybeans has several advantages from a pasture standpoint. The main advantages are (1) high yields (Table 4); (2) abundance of forage in midsummer; (3) high palatability, even of coarse stems, and (4) readiness for pasturing within a short time after seeding (usually 5 to 6 weeks). The mixture is excellent for supplementary use with perennial grass or legume pastures.

It is unwise, however, to use this crop as a staple pasture because of (1) its short season; (2) its loose sod, which cannot be pastured for a day or two after a heavy rainfall; (3) rapid growth, making it difficult to use all forage and causing much to be lost thru the tramping of stock; (4) danger of prussic-acid poisoning; (5) slow recovery after close grazing; and (6) annual expense of seeding.

Sudan grass and soybeans were planted as soon as possible after rye pasturing, at the rate of 25 pounds of Sudan grass and 1.5 bushels of soybeans to the acre.[1] The seeds were mixed on a clean floor and then planted in one operation with a grain drill. If the land had not been planted to soybeans for several years, the soybean seed was inoculated. To avoid prussic-acid poisoning, the crop was not grazed until it was at least 18 inches high.



Seeding Sudan-soybean mixture in late May. The grain drill was used to plant the mixed seed in one operation. As soon as the winter rye was exhausted or too advanced to be eaten readily, the field was plowed and planted to this quick-growing forage.

Grazing began between June 28 and July 7, except in 1939, and ended between September 16 and 25. In 1939, because of the long rye season (27 days) and the heavy rains during the second week of June, planting was postponed until June 21, and grazing did not begin until July 24. The average Sudan-soybean season was 75 to 80 days. The longest season was 90 days, June 28 thru September 25, in 1940.

A plant disease attacked the Sudan grass and spotted the leaves in several seasons. This spotting, or rusting, was worst in 1942. The grass, however, did not lose all its palatability, for the heifers continued to eat it.

Effect of good management. Mowing or close grazing retards the further growth of a Sudan-soybean mixture, especially when the crop has headed out and the stalks have become coarse. If, however, the crop is rested as soon as cattle have eaten the leaves and upper stalks, it

[1]Sudan grass was planted without soybeans in 1939.

Sudan and soybeans produce a crop in a short time. This growth had developed by June 29, the crop having been planted the latter part of May. Pasturing was usually begun during the first or second week of July.

recuperates, puts out a new set of leaves, and is ready in three or four weeks for a second grazing.

Highest yield. A field planted first to rye and then to a mixture of Sudan grass and soybeans yields much more forage than a comparable field planted to a single pasture crop (Table 4, page 240). But even if there were no other disadvantages, the combination still could not be used as a pasture unit because of the disuse of the 2-crop field (for at least a month) between the end of the rye season and the beginning of the Sudan-soybean season (Table 5, page 249).

Sudan-soybean mixture on August 20. The forage provided by this mixture is most abundant during the last half of the pasture season, when bluegrass and similar grasses are at their worst.

This field of Sudan and soybeans is due for a rest. The cattle have eaten most of the leaves and the upper parts of the stalks. The field in the background has been rested and is now ready for a second grazing. Picture was taken August 20.

Abundance of Sudan grass and soybeans on September 8. At this date the bluegrass pasture was dry and bare. Altho the fungus disease that attacks Sudan grass reduced forage yields some years, they were still satisfactory There are few insect enemies of this grass.

TABLE 5.—SEASONAL DISTRIBUTION OF DRY-MATTER YIELDS OF FOUR PASTURE CROPS

(Percent of annual dry-matter yield harvested during each sampling period)

Crop	April 23 to May 9	May 25 to June 9	June 17 to July 6	July 16 to Aug. 12	Aug. 19 to Sept. 1	Sept. 11 to Sept. 30
Alfalfa						
1937	21	23	16	24	9	7
Bluegrass						
1937	25	35	21	13	2	4
1938	16	15	15	19	25	9
1939	17	31	28	6	..	18
1940	10	55	19	4	..	12
1941	16	24	14	18	10	18
1942	13	22	26	18	12	9
Average 1937-1942	16	30	21	13	12	12
Bromegrass						
Average 1941-1942	26	29	11	20	5	9
Sudan-soybeans						
Average 1937-1942	0	0	14	42	25	19

Sudan-soybean pasture resists drouth. Despite the low rainfall in 1940 this field made good pasture until September 25. The bluegrass fields dried up and could not be pastured at all after August 5.

On fertile soils Sudan grows tall. It is not unusual for this grass to reach a height of 7 to 9 feet. This picture was taken on August 17, three days before the one on the preceding page.

Volunteer sweet clover in bluegrass. Altho volunteer sweet clover sprang up in this pasture, the yield of bluegrass remained about the same as usual. The total yield of forage was almost doubled.

Sweet Clover Is Good Midsummer Pasture

Sweet clover has a high yield, resists drouth, and provides much feed during the summer slump in bluegrass. But, like other highly succulent legume crops, in its early stages it is apt to cause too laxative a condition in animals.

After the end of the rye season in 1940 grazing was alternated between sweet clover and bluegrass until the Sudan-soybean pasture was ready. The sweet clover was not used until about June 1, however, as it was too high in water content to make good pasture earlier.

On May 2, when the dry-matter content of the bluegrass was 25 percent, the dry-matter content of the sweet clover was only 11 per-

Sweet clover on June 1. Grazing was alternated between bluegrass and sweet clover from about June 1 until the Sudan-soybean pasture was ready, about July 10. Sweet clover had too high water content to be pastured earlier.

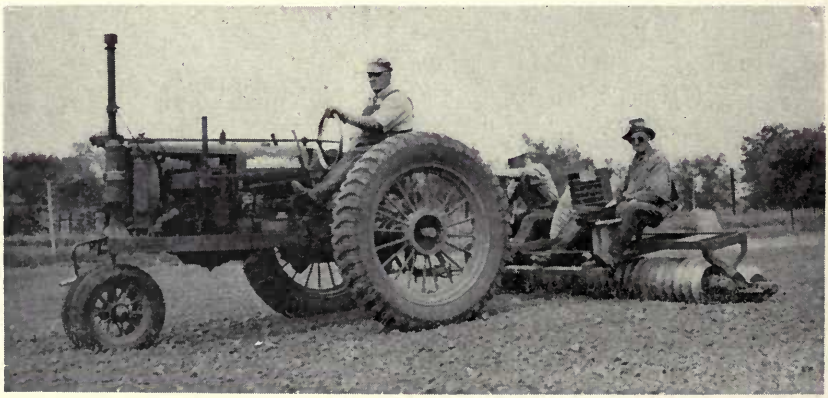
Luxuriant growth of bromegrass on June 2. Altho the grass is headed out, it is still green and palatable. The leaves stay green even after the seed ripens.

cent (Table 12, page 264). Even on June 2, when the dry-matter content of bluegrass was 30 to 36 percent, the dry-matter content of sweet clover was only 15 percent.

Sweet clover, however, was not used enough in these experiments to justify a full discussion of its merits and demerits as a pasture crop for dairy cattle.

Bromegrass Can Be Depended On All Season

Bromegrass is a dependable source of feed during the entire season; it is an especially good crop when pasture space is limited and a fixed



Seeding bromegrass. The seed of bromegrass is so large and light that ordinary seeding implements are not satisfactory. The two men in the back are operating hand seeders, and the double corrugated roller turns a light covering of soil over the seed.

Bromegrass provides green forage in August. Unlike bluegrass and redtop and most other perennial pasture grasses, brome stays green and provides good forage thruout the summer. Picture was taken August 8.

number of cattle must be fed. Midsummer forage is green despite less-than-normal rainfall. Also, it is less expense as well as less work to seed and establish a perennial like bromegrass than an annual like Sudan grass or a biennial like sweet clover.

If, however, it must compete with weeds or fast-growing crops like oats and wheat, bromegrass is slow to establish itself. If it is not grown

Bromegrass establishes itself quickly. It spreads thru root growth as well as by seed and soon develops a firm sod that resists tramping. Picture was taken on August 20, just a year after the field was seeded.

with a legume like alfalfa or sweet clover, the yield usually falls off. Also, bromegrass is slow to recover from close pasturing, and close mowing is apt to kill young plants.

Three fields (Nos. 1, 2, and 8) were planted to bromegrass alone, and yields were well maintained by the heavy application of barnyard manure. Bromegrass was also planted with alfalfa on Field 3 (see page 230).

At the beginning of the season bromegrass furnished more forage than either bluegrass or alfalfa, as shown by Table 3, page 240. The yield was good in midsummer despite heat and drouth, and the leaves remained green even when a seed crop matured.

Bromegrass, it was found, should not be pastured when it is less than 6 inches tall. Likewise clipping, if to control weeds, should not reduce the height of the plants to less than 6 inches. Clipping to remove headed seed stalks is unnecessary.

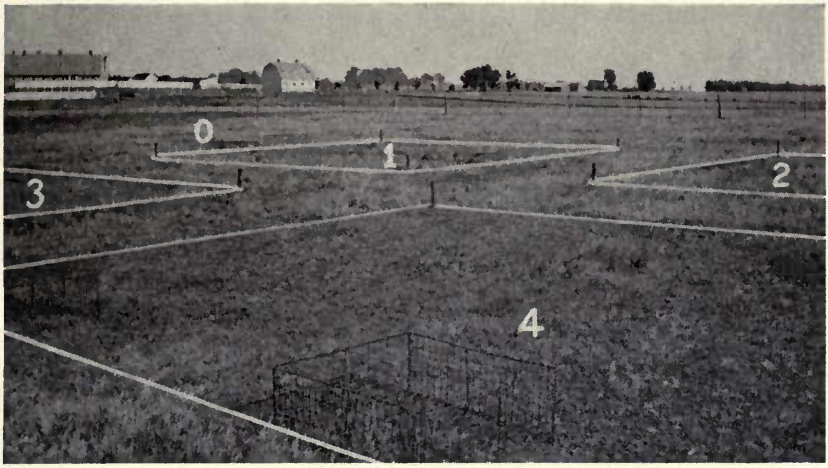
Forage Yields Varied With Year

Yearly yields in these tests (Table 4, page 240) varied mainly because of differences in rainfall and temperature. There were other reasons, however, for yearly variations: (1) the planting dates of the annual crops—winter rye, Sudan grass, and soybeans—were not the same each year; (2) grazing was more intensive some seasons; (3) stands of crops, especially bromegrass and alfalfa were thicker some years than they were other years; and (4) each application of barnyard manure tended to restore or increase the fertility of the soil.

COW URINE IS A GOOD FERTILIZER

The urine of cows is a valuable source of both nitrogen and potassium. From one-third to one-half of the nitrogen and at least three-fourths of the potassium that a dairy cow excretes is in her urine. For every ton of feces she excretes, she urinates 12 to 16 pounds of nitrogen and 10 to 12 pounds of potassium. Cow urine, however, has only a trace of phosphorus.

From 1939 thru 1942 cow urine was applied to four plots, each 2 rods square, which were laid out in a well-sodded and nearly level part of a bluegrass field (see pages 230 and 255). The plots were separated from one another by 1-rod borders. No fencing other than short posts at the four corners of each plot were used, so that cattle had equally free access to all plots and to the rest of the field.



Bluegrass plots treated with cow urine. The plots that received the heaviest applications (Nos. 3 and 4) have been most closely grazed. The grass on these plots had a higher protein content than the grass on the other plots.

The urine used contained about 1 percent of nitrogen and 1 percent of potassium (Table 6). It was collected from high-producing dairy cows into clean pails during the act of urination. Within a few hours it was applied to the plot by means of garden sprinkling cans. Whenever the moisture in the surface soil was low, the urine was mixed with an equal volume of water; otherwise it was applied undiluted.

The rates of application at each treatment were:

	Pounds an acre		*Pounds an acre*
Plot 1	1,250	Plot 3	3,750
Plot 2	2,500	Plot 4	5,000

About once a month samples were taken from the four treated plots and from an untreated area. The grass portions were then analyzed to determine their dry matter and protein contents.

Forage Yields Increased

All treated plots produced much more forage than the untreated remainder of the field. Also plots that received heavy applications tended—altho there were some exceptions—to have higher yields than plots that received light applications (Table 7).

As this treatment of the four plots with cow urine was in addition

TABLE 6.—NITROGEN AND POTASSIUM IN SAMPLES OF COW URINE APPLIED TO BLUEGRASS PLOTS
(Percent)

Date of application	Nitrogen	Potassium	Date of application	Nitrogen	Potassium
April 8, 1939	1.08	1.12	May 17, 1941	.85	1.00
May 11, 1939	1.07	1.22	June 10, 1941	1.12	1.05
June 12, 1939	1.11	.91	May 7, 1942	.92	.86
June 8, 1940	1.29	1.04	Average	1.09	1.03
April 14, 1941	1.25	1.07			

to the annual treatment with barnyard manure (pages 229-230), it is evident that a good way to improve bluegrass pasture is by saving as much as possible of the urine excreted during the barn-feeding season and applying it to pastures when grass is making its early growth in the spring. Some progressive farmers have drains which carry the urine from gutters in the stable to storage cisterns or tanks.

Protein Content Increased

In most instances cow urine increased the protein content of bluegrass, and the more urine was applied the richer the grass was in protein (Table 8). Exceptions occurred when pastures were nearly dormant in August and September of some seasons.

A samples had a higher protein content than B samples. This was probably because the A samples represented only new growth, while the B samples included both new growth and older forage.

TABLE 7.—YIELDS OF TOTAL FORAGE AND OF GRASS ON BLUEGRASS PLOTS FERTILIZED WITH DIFFERENT AMOUNTS OF COW URINE
(Pounds of dry matter per acre)

Year	Plot 0 No treatment	Plot 1 Light treatment	Plot 2 Medium treatment	Plot 3 Heavy treatment	Plot 4 Very heavy treatment
			Forage including weeds		
1939	2 580	3 300	3 130	3 740	4 600
1940	2 190	3 500	3 810	3 560	4 260
1941	2 850	4 050	4 530	3 860	4 840
1942	3 010	4 200	4 110	4 520	4 370
Average	2 660	3 760	3 900	3 920	4 520
			Grass portion		
1939	2 320	3 140	3 090	3 440	4 310
1940	2 040	3 400	3 690	2 980	3 760
1941	2 370	3 600	4 080	3 400	4 280
1942	2 170	3 450	2 980	2 740	2 920
Average	2 220	3 400	3 460	3 140	3 820

TABLE 8.—PERCENT OF DRY MATTER AND OF PROTEIN IN BLUEGRASS TREATED WITH DIFFERENT AMOUNTS OF COW URINE
(Averages of four seasons, 1939-1942)

Plot	Treatment	April 29-May 5		May 25-June 7		July 2-16		August 1-19		September 11-29	
		Dry matter	Protein in dry matter	Dry matter	Protein in dry matter	Dry matter	Protein in dry matter	Dry matter	Protein in dry matter	Dry matter	Protein in dry matter
		C samples		A samples							
0	None	26.3	18.0	29.2	11.3	34.3	13.4	30.1	14.3	38.4	17.7
1	Light	26.8	19.3	32.7	13.4	33.0	15.8	33.3	15.5	37.3	18.4
2	Medium	26.3	23.6	32.3	15.9	30.2	16.2	31.0	15.6	34.8	20.9
3	Heavy	24.1	21.8	30.3	17.3	30.1	17.9	28.7	16.0	33.8	20.2
4	Very heavy	24.9	22.3	30.8	18.1	30.7	18.2	33.8	17.1	36.2	21.3
		B samples									
0	None	....	....	36.2	9.4	43.5	8.6	41.5	10.4	44.9	14.0
1	Light	....	....	34.2	10.6	39.1	10.8	41.2	12.2	41.5	15.4
2	Medium	....	....	35.9	12.1	38.0	11.5	36.9	13.4	39.8	17.2
3	Heavy	....	....	33.3	14.6	35.9	14.1	40.7	13.5	40.2	17.1
4	Very heavy	....	....	34.2	14.8	36.4	14.8	36.5	15.7	35.5	19.4

NOTE.—For method of sampling see page 230.

The effect of the urine treatment on protein content also carried over a little from year to year. In 1940 and 1942, for example, grass was sampled before urine was applied; and the C samples from plots treated with urine the season before were richer in protein than the C samples from plots not treated with urine the season before.

Palatability Increased

From 1938 thru 1942 four different groups of heifers grazed the bluegrass field where plots were treated with cow urine. All four

TABLE 9.—PALATABILITY OF BLUEGRASS FERTILIZED WITH DIFFERENT AMOUNTS OF COW URINE AS DETERMINED BY FORAGE LEFT ON OPEN PASTURE
(Average of four years, 1939-1942)

Plot	Treatment	Forage including weeds			Grass portion		
		Annual dry-matter yield in pounds per acre	Average left on open pasture on sampling dates[a]		Annual dry-matter yield in pounds per acre	Average left on open pasture on sampling dates[a]	
			Pounds per acre	Percent of annual dry-matter yield		Pounds per acre	Percent of annual dry-matter yield
0	None	2 660	750	28	2 220	660	30
1	Light	3 760	830	22	3 400	810	24
2	Medium	3 900	640	16	3 460	590	17
3	Heavy	3 920	550	14	3 140	480	15
4	Very heavy	4 520	590	13	3 820	520	14

[a]Each figure is the average of 22 C samples, which were taken thruout the season during four years. The pasture had not been grazed when the first C sample was taken each season.

groups found the treated plots more palatable. Altho Plot 1 looked about like the untreated part of the pasture in some seasons, it was always obvious that Plot 2 was more intensely grazed than the untreated part of the pasture, also that Plots 3 and 4 were more intensely grazed than Plots 1 and 2.

Relative palatability of the plots was measured fairly exactly by the **C** samples taken on the 22 harvest dates over the four years (Table 9). As heifers had equal access to all parts of the bluegrass field, the **C** sample, which showed the amount of forage left on each plot, was a good gage of how intensely they had grazed it, or how palatable the forage was.

More forage was left on the untreated plot (0) than on the treated plots, and on the lightly treated plots (1 and 2) than on the heavily treated plots (3 and 4). Thus palatability, or intensity of grazing, tended to vary in proportion to the amount of cow urine applied.

CHANGES IN PALATABILITY AND FEEDING VALUE

Why do cattle prefer young, green grass to ripe, brown grass? Why does the young grass promote better growth in cattle? Why, when two crops such as bluegrass and sweet clover are equally tall before grazing, will cattle do well on one and poorly on the other?

Chemical studies answer these and similar questions, at least in part.

Palatability Linked With Moisture Content

Altho the bluegrass treated with cow urine was richer in protein, this by itself did not explain why four different groups of heifers sought out the same small area in the middle of the 4½-acre field and grazed it most intensely. As likely factors were the high mineral and vitamin contents of the treated area. Also the treated bluegrass, since it stayed greener and matured more slowly, lignified later.

Palatability was probably directly related to moisture content, for the treated bluegrass had a consistently higher moisture content (lower dry-matter content) than the untreated (Table 10).

From 1939 thru 1942 the averages of 201 samples from four treated plots were compared with the averages of 268 samples from five untreated plots. Out of the 53 comparisons so made, 37 showed a lower dry-matter content in the treated bluegrass; 4, no difference; and 12, a higher dry-matter content in the treated bluegrass. The high dry-

TABLE 10.—DRY-MATTER CONTENT OF FERTILIZED AND UNFERTILIZED BLUEGRASS
(Percent)

Date of sampling	A samples			B samples			C samples		
	Unfertilized plots (average of 5)	Fertilized plots (average of 4)	Decrease when fertilized	Fertilized plots (average of 4)	Unfertilized plots (average of 5)	Decrease when fertilized	Unfertilized plots (average of 5)	Fertilized plots (average of 4)	Decrease when fertilized
1939									
May 5	....	....	....	....	....	....	30.7	34.3	(+3.6)
June 7	41.6	40.7	.9	46.1	43.1	3.0	49.5	47.8	1.7
July 5	35.1	33.2	1.9	41.5	38.5	3.0	40.6	38.6	2.0
August 8	....	....	....	47.2	43.6	3.6	49.9	49.4	.5
September 11	37.9	37.9	0	45.5	40.8	4.7	....	....	....
1940									
May 2	....	....	....	....	....	....	27.8	23.7	4.1
June 6	31.4	28.6	2.8	34.8	30.1	4.7	35.0	33.5	1.5
July 5	37.5	29.7	7.8	44.1	36.7	7.4	49.9	39.6	10.3
August 12	....	....	....	41.5	46.9	(+5.4)	40.5	42.9	(+2.4)
September 26	....	....	....	54.2	51.0	3.2	....	....	....
1941									
April 29	....	....	....	....	....	....	27.1	22.5	4.6
May 26	36.2	31.2	5.0	33.2	33.2	0	36.8	35.1	1.7
June 17	37.7	37.1	.6	43.6	39.2	4.4	45.9	45.9	0
July 16	33.6	30.5	3.1	45.0	39.5	5.5	47.2	44.5	2.7
August 19	41.1	36.5	4.6	50.1	37.4	12.7	54.7	44.1	10.6
September 15	35.9	29.2	6.7	37.8	31.2	6.6	43.5	47.5	(+4.0)
1942									
April 30	....	....	....	....	....	....	29.4	22.7	6.7
May 25	28.2	26.2	2.0	29.3	31.2	(+1.9)	31.2	31.2	0
June 29	29.1	31.3	(+2.2)	33.3	34.7	(+1.4)	38.5	42.0	(+3.5)
July 31	30.6	26.4	4.2	35.0	27.0	8.0	42.7	32.3	10.4
August 31	27.7	30.5	(+2.8)	30.0	35.0	(+5.0)	33.7	36.1	(+2.4)
September 29	33.8	38.3	(+4.5)	41.3	38.8	2.5	41.0	38.7	2.3
Mean of differences	....	....	2.007	....	....	3.088	....	....	2.16
Standard deviation	....	....	3.35	....	....	4.43	....	....	4.44
Student's odds 1:	....	....	46	....	....	193	....	....	49

Palatable new growth of bluegrass on September 16. Showers and cooler weather in late summer and fall usually cause renewed growth, which is much more palatable than the dry grass of midsummer. The fact that fertilized bluegrass has a higher moisture content than unfertilized bluegrass is believed to account for its greater palatability.

Sudan grass stays moist and palatable. Its high moisture content thruout most of the pasture season is believed to be one reason why dairy cows find this crop so palatable. Even the coarse stems are eaten. Picture was taken on September 5.

matter content of the treated grass occurred mostly in 1942, when rainfall was below normal from July 16 to August 23 (Table 2).

An analysis of the data (Table 10) by Student's method[1] shows that the odds against the differences in dry-matter content being caused by chance were 46 to 1 for the **A** samples; 193 to 1 for the **B** samples, and 49 to 1 for the **C** samples.

Further evidence that low dry-matter content might be a factor in determining the palatability of pasture crops was sought by additional study of the crops used in these trials. Analysis of samples taken during the months of April to September inclusive, in five of the six years of these tests, showed that the bluegrass contained more than 30 percent of dry matter thruout a large part of the pasture season, whereas the Sudan-soybean pasture rarely reached as high as 30 percent.

	Number of samples	*Samples containing more than 30 percent of dry matter*	
		Number	*Percent*
Alfalfa	71	17	24
Bluegrass	380	359	92
Bromegrass	30	9	30
Sweet clover	16	6	38
Sudan-soybeans	38	1	3

It was observed that the bluegrass, except during the rainy periods of early spring and early fall, when growth was luxuriant, was of much less interest to the cattle than Sudan grass, which was readily grazed thruout most of the summer even tho it has large coarse stems. It is assumed, therefore, that the lower dry-matter content of such crops as Sudan grass is in large measure responsible for their high palatability.

Feeding Value Declines as Forage Matures

Thruout 1941 samples of bluegrass from the untreated plot (0) and the most heavily treated plot (4) were analyzed to determine their contents of dry matter, protein, lignin, and cellulose at different times during the season (Table 11). In order to have a better basis for making comparisons, similar analyses were made of bromegrass and winter rye in 1942.

(Lignin and cellulose are the two compounds that make up most

[1]STUDENT. The probable error of a mean. Biometrika 6, Part 1, page 19. 1908.

TABLE 11.—FEEDING VALUE OF BLUEGRASS (TREATED AND UNTREATED), BROMEGRASS, AND WINTER RYE AT DIFFERENT STAGES OF DEVELOPMENT

Date of harvest	Cow urine applied	Dry-matter content	Protein and fiber in dry matter		
			Protein	Lignin	Cellulose
Bluegrass (B samples)					
1941		*perct.*	*perct.*	*perct.*	*perct.*
April 29	None	26.7	19.6	12.2	23.4
	Very heavy	24.4	28.8	9.5	22.2
May 26	None	36.4	9.9	18.3	33.3
	Very heavy	32.9	17.0	22.0	31.0
June 17	None	47.0	8.3	19.0	32.0
	Very heavy	36.8	17.1	24.0	31.1
July 16	None	50.8	7.5	18.1	34.5
	Very heavy	39.0	14.3	21.8	32.6
August 19	None	52.7	8.5	16.9	31.3
	Very heavy	36.2	16.6	19.8	27.7
September 15	None	40.0	13.1	21.9	31.4
	Very heavy	25.8	26.8	21.9	24.4
Bromegrass (B samples)					
1942					
April 23		22.5	21.5	14.3	21.8
May 9		22.7	15.8	15.3	28.1
May 25		26.0	8.9	16.6	35.4
July 2		34.8	8.6	16.9	32.8
August 3		37.8	10.0	19.6	32.5
August 31		48.7	9.4	21.2	35.2
September 29		43.4	10.6	19.7	32.9
Winter rye (C samples)					
1942					
April 23		18.8	17.7	10.5	21.8
April 30		15.1	15.2	13.1	30.9
May 9		24.5	10.3	15.4	30.8

of the fibrous part of a farm crop. In ordinary analyses they are classed together as "crude fiber." Cellulose, however, is digestible by livestock, while lignin is indigestible. It is important, therefore, to know how much of the fibrous part of a pasture crop is cellulose and how much is lignin.)

At the beginning of the season the dry-matter and lignin and cellulose contents of bluegrass were low. A month later they had increased and, except for a slight drop in August, stayed at about the same level the rest of the season. The protein content, however, declined as the grass developed. These seasonal changes in composition were characteristic of both treated and untreated grass.

Bromegrass and winter rye showed a less abrupt rise in dry matter, lignin, and cellulose. Their protein content also gradually declined until it was only about half as great as it was early in the season.

Getting an early start with winter rye. Winter rye not only furnishes abundance of pasture early in the spring but also makes it possible to delay pasturing bluegrass and bromegrass until they have developed a heavy growth, thus lengthening the pasture season two or three weeks.

The dairy cow on young, growing grass in the spring, therefore, may get all the protein she needs. But as the season progresses and the protein content of the pasture becomes less, she is likely to need protein supplements in increasing amounts.

Bromegrass is another excellent early pasture crop. Altho later than winter rye, bromegrass furnishes more forage than bluegrass at the start of the season. Picture was taken early in May.

Early Pasture Cannot Be Judged by Appearance

First samples—those taken just before heifers were turned on pasture, around May 1—showed that the bromegrass and winter rye consistently yielded more forage than the bluegrass at the beginning of the season (Table 3, page 240). Sweet clover, during the one year when results were available, yielded no more forage than bluegrass at this time (around May 1); nor in some seasons was alfalfa any more advanced than bluegrass.

The yield of a crop at the beginning of one season, however, was no indication what the yield would be at the beginning of the next season. On May 2, 1940, for instance, the bluegrass yielded only 300 pounds an acre, while bluegrass on slightly earlier dates in 1940 and 1942 yielded double this amount. Rye fluctuated even more: the yield on the first sampling date in 1942 was three times as great as the yield on the first sampling date in 1941.

TABLE 12.—DRY-MATTER CONTENT OF GRASS PORTION OF FIVE PASTURE CROPS ON FIRST SAMPLING DATES, C SAMPLES
(Percent)

Crop	May 6, 1937	April 26, 1938	May 5, 1939	May 2, 1940	April 29, 1941	April 23, 1942
Alfalfa	14.4	20.2	....	....	20.6	23.9[a]
Bluegrass	24.2	26.5	30.7	28.7	27.3	31.0[b]
Bromegrass	....	....	....	....	15.3	23.9
Sweet clover	....	....	....	11.3	....	....
Winter rye	31.8	17.0	16.9	15.4	17.4	19.0

[a]Mixture of alfalfa and bromegrass. [b]This sample was taken on April 30 instead of April 23.

The percentage of dry matter in the different crops varied a great deal also at this time of year (Table 12). On May 2, 1940, for example, sweet clover contained 11.3 percent of dry matter; winter rye, 15.4 percent; bluegrass, 28.7 percent.

Forage, moreover, is often deceiving in appearance, bluegrass that is 6 to 8 inches tall before grazing usually containing much more dry matter than sweet clover that is the same height. The inexperienced dairy farmer who depends upon pasture for the sole ration in early spring must therefore proceed cautiously.

WEEDS ARE MAJOR PROBLEM

Most weeds not only make forage unpalatable but are also likely to impair the flavor of milk.

Much hay and straw were bought to feed and bed the cattle at the experimental farm. Barnyard manure applied to the pastures undoubtedly contained many weed seeds. When the fields were fertilized once a year, therefore, weed seeds were spread with the manure. The weed content of some crops, such as rye, however, was consistently small, while the weed content of other crops, such as bluegrass, was consistently large. *The weed content of pasture forage is evidently related to the kind of pasture crop* (Table 13).

Alfalfa becomes weedier each year. Alfalfa was less weedy in April, May, and June than during the rest of the season. **A** samples were highest in weed content and **C** samples lowest, altho differences were not large. Weed content was comparatively low during the first pasture season (next year after seeding) but increased until, toward the end of the third year of pasturing, bacterial wilt killed many alfalfa plants. This thinning of the alfalfa stand encouraged the heavy growth of common annual weeds such as foxtail, pigweed, common ragweed, smartweed, and crabgrass.

Dandelions predominate in bluegrass. Dandelions made up the bulk of the weed portion of bluegrass. As dandelions become largely

TABLE 13.—WEED CONTENT OF FIVE PASTURE CROPS
(Percent in dry matter)

Crop	Total number of usable samples	April	May	June	July	August	September	Average
Alfalfa, 1937, 1938, 1941, 1942								
A sample	28	..	12	32	27	50	19	28
B sample	30	..	10	9	15	37	32	26
C sample	21	1	..	2	26	49	31	22
Average	79	1	11	9	23	45	26	26
Bluegrass, 1935-1942								
A sample	121	..	17	19	29	21	23	22
B sample	134	..	20	12	14	13	13	14
C sample	155	26	14	7	7	7	9	10
Average	410	26	16	13	16	14	15	15
Bromegrass, 1941 average	32[a]	48	26	5	0	2	5	12
Bromegrass, 1942 average	55[b]	0	(c)	1	0	0	0	(c)
Winter rye, 1937-1942 average	31	0	(c)	..	..	..	..	(c)
Sudan-soybeans, 1937-1942 average	41	..	..	0	3	1	4	2

[a]First year after seeding. [b]Second year after seeding. [c]Less than .5 percent.

dormant after July unless rainfall is above normal, bluegrass was usually weediest early in the season. Also **A** samples were nearly always weedier than **B** and **C** samples: the frequent cutting and protection of the **A** areas seemed to retard the growth of the grass, and dandelions made up a larger proportion of the forage there. The heifers (which received no supplementary feed) ate the dandelions readily, and after July 1 both grass and weeds were closely grazed. The milk cows that

TABLE 14.—WEED CONTENT OF BLUEGRASS (C SAMPLES) DURING GRAZING MONTHS OVER EIGHT-YEAR PERIOD, 1935-1942

(Percent of total dry-matter yield which was in weed portion)

Year	April	May	June	July	August	September
1935	..	..	..	..	4	3
1936	..	6	4	0	4	(a)
1937	..	10	2	6	7	2
1938	19	5	11	9	13	12
1939	..	24	4	9	2	8
1940	..	9	8	5	2	47[b]
1941	19	24	15	9	7	11
1942	40	21	15	15	14	26

[a]Less than .5 percent. [b]In this season of low rainfall the September **C** samples of two fields showed only 356 pounds of total forage per acre; two other fields were so bare that no **C** samples could be taken.

were fed supplements in the preliminary trials in 1935 and 1936, however, avoided the dandelions.

Foxtail, lamb's quarters, common ragweed, and sorrel appeared in the bluegrass in small amounts. Dock and other large weeds were dug out by hand; and the sod, altho filled with dandelions, was always heavy. Yet the weed content of the bluegrass did not decline from year to year (Table 14). The percentage of weeds in 1941 and 1942—perhaps because of heavier stocking then—was even higher than in the earlier years.

Bromegrass becomes less weedy each year. The April and May samples of the first bromegrass season (first pastured on May 17, 1941, after seeding in August, 1940) were 25 to 50 percent weeds (Table 13). Foxtail, pigweed, lamb's quarters, crabgrass, and other annuals predominated. As the season progressed, the stand of bromegrass became more dense and the percentage of weeds decreased. By the end of the second year of pasturing, the forage was practically free from weeds.

Rye and Sudan-soybeans have low weed contents. The twice-yearly plowing or thoro cultivation of the two-crop pastures kept the weed content of rye at a minimum. Weeds, when present at all in rye, usually made up less than .5 percent of the dry matter (Table 13).

Bromegrass prevents weed growth. After the bromegrass pastures became well established during their second year, they were remarkably free from annual weeds such as ragweed, foxtail, and smartweed, and also from dandelions. This picture was taken September 16, a time when weeds are especially troublesome in most pastures. The growth of tall-growing perennial weeds such as curled dock and Canada thistle was not prevented, altho their spread may have been retarded.

Sudan-soybean pasture almost free of weeds. The twice-yearly plowing of this field (once for rye and once for the Sudan-soybean mixture) kept the weeds, except a few velvet weeds that appeared late in the season, at a minimum. Winter rye pastures were practically free of weeds.

The Sudan-soybean mixture also benefited from the twice-yearly seedbed preparation. Velvet weed, however, was rather troublesome here. It was controlled by being pulled by hand, removed from the field, and burned. Common pigweed and crabgrass appeared in small amounts during the latter part of some seasons.

Curled dock affects several crops. Curled dock appeared in alfalfa, bluegrass, and bromegrass and was dug out by hand nearly every year. Its incidence seemed to have little or no relation to the kind of pasture crop except that plowing twice yearly in preparation for the growing of winter rye and the Sudan-soybean mixture formed an effective control.

Weed-resistant crops have low dry-matter content. A study (Table 15) was made of the dry-matter levels of the grass and weed portions in the samples of three crops—alfalfa, bluegrass, and bromegrass. Many samples of each crop could not be used for this purpose, however, because they contained no weeds or at least not enough to make a reliable determination of the dry-matter content of the weed portion. Out of the 513 bluegrass samples taken over the four years, for example, only 133 were usable in the study.

The grass portion of the bluegrass forage—the crop lowest in yield—always had a higher percentage of dry matter than the corresponding weed portion. The mean values for all 133 samples were 37 percent dry matter in the grass portion and 20 percent dry matter in the weed portion.

The difference in dry-matter content between the grass and weed portions of alfalfa and bromegrass—both crops with high yields—was small. Out of 53 alfalfa samples only 11 had a higher percentage of dry matter in the weed portion than in the grass portion. Out of 21 bromegrass samples 13 had a higher percentage of dry matter in the weed portion than in the grass portion.

One reason bluegrass was such a poor competitor of weeds may well

TABLE 15.—AVERAGE DRY-MATTER CONTENT OF GRASS AND WEED PORTIONS OF THREE PASTURE CROPS

Crop	Total number of usable samples	Dry matter in grass portion	Dry matter in weed portion
		perct.	*perct.*
Alfalfa, 1937, 1938, 1941, 1942	53	28	24
Bluegrass, 1939-1942	133	37	20
Bromegrass, 1941-1942	21	23	25

be that during much of the season it was in an inactive or partially inactive stage of vegetation (as evidenced by its high dry-matter content), whereas the weeds during most of the season were in an active vegetative stage (as evidenced by their low dry-matter content).

SUMMARY AND CONCLUSIONS

Rotational grazing increases the yield and feeding value of pastures. Bluegrass is usually not satisfactory to use as the only pasture crop for dairy cattle in central Illinois because of its low yields and low feeding value during midsummer. These two faults can be somewhat overcome by good management practices such as fertilizing heavily, beginning grazing only after good growth of the grass, removing cattle early in the autumn, and digging out large perennial weeds.

A more effective way to get more and better forage from the same amount of pastureland, however, is to use several pasture crops—such as winter rye, bluegrass, alfalfa, a Sudan-soybean mixture, bromegrass, and sweet clover—in rotation. The mixture of Sudan grass and soybeans, for instance, makes a high-yielding and drouth-resistant midsummer pasture.

Rotational grazing lengthens the pasture season. Winter rye is ready for grazing one to two weeks earlier than bluegrass, and bromegrass is ready several days earlier than bluegrass. In seasons of low rainfall the rotational system furnishes pasture for a longer time than bluegrass.

Yield is not the only measure of pasture value. For example, a pasture planted first to winter rye and then to a mixture of Sudan grass and soybeans usually has a much higher yield than a pasture planted just to one crop, but the supply of forage is not continuous. Likewise, while both alfalfa and bromegrass have higher yields than bluegrass, alfalfa needs reseeding more often, and bromegrass does not recover from close grazing so quickly.

Pasture crops for dairy cattle should be rated not only on total yield but also on (1) feeding value, (2) palatability, (3) economy of production, (4) timeliness of yield, (5) length of pasture season, (6) resistance to drouth, weeds, and tramping, (7) likelihood of causing bloat or other upsets, and (8) adaptability to soil and climate.

Fertilizing with cow urine improves pastures markedly. Fertilizing with cow urine in addition to manure increases the yield, protein

content, and palatability of bluegrass. The lower dry-matter content (higher moisture content) of fertilized grass probably explains its greater palatability: urine-treated grass has a consistently lower dry-matter content than untreated.

Feeding value of most crops changes as season advances. As bluegrass, bromegrass, and winter rye develop, the dry-matter, lignin, and cellulose contents rise. At the same time the protein content gradually falls, until the forage contains only about half as much protein as it does at the beginning of the season. There appears to be a close relation between low dry-matter content (high moisture content) and palatability.

Weeds are a major problem. Some crops tend naturally to be weedy; the weed content of bluegrass pastures in these experiments did not decline despite good management for eight years. Bromegrass, winter rye, and the Sudan-soybean mixture made good dairy pastures because of their low weed content and their high yields.

PREVIOUSLY PUBLISHED PROGRESS REPORTS OF THIS INVESTIGATION

Improved dairy pastures possible thru new studies. Ill. Sta. Ann. Rpt. 49, p. 141. 1937.

Improvement in dairy pastures possible. Ill. Sta. Ann. Rpt. 50, p. 156. 1939.

Cows' urine as a fertilizer for bluegrass pastures. Jour. Dairy Sci. **24**, 761. 1941.

Higher yields from dairy pastures obtained in tests. Ill. Sta. Ann. Rpt. 51, p. 147. 1942.

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Pastures for corn-belt dairy farms. Amer. Dairyman **2**, 22-23, 29. 1942.

Results of experiments in improvement of pastures for dairy cattle. Ill. State Acad. Sci. Trans. 35, 35. 1942.

Relation of kind of pasture crop to weed content of forage. Jour. Dairy Sci. **26**, 877. 1943.

REVIEWS OF PASTURE RESEARCH

Readers who are interested in reviews of other research on pasture problems are referred to the following works:

DAHL, A. S. Abstracts of pasture literature. U. S. Dept. Agr. Soil Conservation Service. 1937.

PIETERS, A. J. A digest of pasture research literature in the continental United States and Canada, 1885 to February 1937. U. S. Dept. Agr. Bur. Plant Indus. 1937.

———— A digest of some world pasture research literature (exclusive of continental United States and Canada). U. S. Dept. Agr. Bur. Plant Indus. 1937.

CURRENT PUBLICATIONS ON PASTURE CROPS

The following bulletins and circulars of the Illinois Agricultural Experiment Station and Extension Service give information about the culture and use of various pasture crops in Illinois:

Pasture Improvement and Management. Circular 465. 52p.
Bromegrass and Bromegrass Mixtures. Bulletin 496. 20p.
Supplementing and Improving Dairy Pastures. Circular 553. 8p.
Sweet Clover for Illinois. Circular 559. 24p.
How to Get Good Yields of Alfalfa. Circular 560. 16p.
Lespedeza, Its Place in Illinois Agriculture. Circular 561. 20p.

Anyone desiring these publications can obtain them free of charge by writing the COLLEGE of AGRICULTURE, URBANA, ILLINOIS.

ABUNDANT GREEN FORAGE from early spring to late fall is the dream of every dairy farmer. Midsummer pastures are, however, a problem in Illinois, for the hot dry weather that comes then often stunts or destroys the forage and causes serious loss in milk yields.

Rotational grazing with a variety of pasture crops—winter rye, bluegrass, alfalfa, a Sudan-soybean mixture, bromegrass, and sweet clover—along with good management, seems to be the solution to this problem, as demonstrated by the tests reported in this bulletin.

Each of these crops has certain merits and certain shortcomings. By combining them in a rotation system, Illinois dairy farmers, particularly those in the central and northern parts of the state, can work out plans that will give them good forage thruout the pasture season.

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